Title: Math and Science are Probably Connected

Brief Overview:

This is an interdisciplinary unit which uses the basics of probability to link concepts in Chemistry, Genetics, and Physical Science. Students will collect, organize, and analyze data; construct graphs and charts, and use writing to communicate what they have learned.

Link to Standards:

- **Problem Solving** Students will demonstrate their ability to solve Mathematics/Science problems through probability calculations.
- **Communication** The student will be able to communicate to his/her peers the data gathered from these experiments and what effect they have on the outcome of each experiment.
- **Reasoning** Students will make predictions and experiment to check results.
- **Connections** The student will be able to make connections between the mathematics concepts used in these experiments and real-life applications.
- **Statistics** Students will collect, organize and analyze data (i.e. construct frequency charts, graphs, and data tables.)
- **Probability** Students will predict and determine probability by means of mathematical calculations and check through experimentation. They will also use simulations to develop a model for real-life situations.
- **Measurement** Students will use measurement to complete the physics extension.

Grade/Level:

Grades 6 - 8

Duration/Length:

3 to 5 days.

Prerequisite Knowledge:

Students should have working knowledge of the following skills:

- Number Concepts and Relationships
- Using the TI-80
- Basics of gravity
- Basics of probability
- Basics of heredity

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Extension I
Physical Science

Objectives:

Students will (or Students will be able to):

- hypothesize the effects of gravity on the probability of rolling a certain number on one did.
- construct a frequency chart, and histogram to illustrate their data.
- analyze the data to determine the effects of gravity on probability

Materials/Resources/Printed Materials:

- TIC 80 Graphing Calculator
- Graph Paper and Lined Paper
- Rulers and Yard Sticks
- Three different sizes of dice for each group
- 5 foot piece of felt, 5 foot piece of plastic/rubber, 5 foot section of concrete/asphalt/grass/etc. for each group.
- Student worksheets 1-3
- Teacher Instruction page.
- Assessment Student Worksheet

Development/Procedures:

- Divide the class into groups of three. Each person is assigned a task: task performer, recorder, and observer.

- Perform Experiment I: Write the hypothesis.
  Tape yard stick securely to the wall. Drop a die from a height of five inches 24 times.
  Drop a die from a height of 10 inches 24 times.
  Drop a die from a height of 15 inches 24 times.
  Record all results on a separate piece of paper.
  Complete Student Worksheet #1.
- Perform Experiment II: Write the hypothesis.
  Drop the small die from a height of five inches 24 times.
  Drop the medium die from a height of five inches 24 times.
  Drop the larger die from a height of five inches 24 times.
  Record all the results on a separate piece of paper.
  Complete Student Worksheet #2.
- Perform Experiment III: Write the hypothesis.
  Roll the die 24 times on the felt surface.
  Roll the die 24 times on the plastic/rubber surface.
  Roll the die 24 times on the concrete/asphalt/grass/etc.
  Record all the results on a separate piece of paper
  Complete Student Worksheet #3
- Complete Assessment Worksheet

Evaluation:

The Assessment for this piece will be the student's creation of a fourth experiment which will test the effects of gravity on a probability test. Dice should not be used for this experiment. (Other equipment might include spinners, coins, bingo ball, etc.)

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Worksheet for Experiment #1

Name _____

Date _____

Purpose: To determine how gravity effects probability when rolling dice.

Materials: Yard stick, tape, six-sided die, graph paper, TI-80 calculator.

Procedures:

1. Write a hypothesis for the probability of rolling a "3" from three different heights.

Hypothesis:

_____
_____
_____

2. Tape a yardstick vertically to a wall where there is space to work.
3. Drop the die 24 times from a height of 5 inches. Record your results on a separate sheet.
4. Drop the die 24 times from a height of 10 inches. Record your results on a separate sheet.
5. Drop the die 24 times from a height of 15 inches. Record your results on a separate sheet.
6. Create a frequency chart using the results of this experiment.

Side of Die

	1	2	3	4	5	6
5 INCHES						
10 INCHES						
15 INCHES						

Based on 24 trials at each height.

7. Create a histogram illustrating the frequency of rolling a "3" from the heights of 5", 10" and 15".

QUESTIONS

1. What are the odds of rolling a "3" when dropping the die from a height of 10 inches?

2. Using the TI-80 Graphing calculator, what is the probability of rolling a "3" from a height of 25 inches?

3. Explain why using the calculator would help you understand the effects of gravity on the die.

Worksheet for Experiment #2

Name_____

Date_____

Purpose: To determine how gravity effects probability when rolling dice.

Materials: 3 six sided dice, each a different size, a ruler, graph paper.

Procedures:

1. Write a hypothesis for the probability of rolling a "4" using three different-sized dice.

Hypothesis:

_____
_____
_____

2. Using the ruler, drop the smallest die 24 times from a height of 5 inches. Record your results on a separate sheet.
3. Drop the middle-sized die 24 times from a height of 5 inches. Record your results on a separate sheet.
4. Drop the largest die 24 times from a height of 5 inches. Record your results on a separate sheet.
5. Create a frequency chart using the results of this experiment.

Side of Die

	1	2	3	4	5	6
SMALL						
MEDIUM						
LARGE						

Based on 24 trials at each height

6. Create a histogram illustrating the frequency of rolling a "4" with each size die.

QUESTIONS

1. Which data organization method (frequency chart or histogram) is more beneficial when explaining the results of this experiment? Explain your answer.

2. Why might the size of the die effect the results of this experiment?

3. Would the odds of rolling a "7" on the largest die be the same as rolling a "4"? Explain your answer.

Worksheet for Experiment #3

Name_____

Date_____

Purpose: To determine how gravity effects probability when rolling dice.

Materials: 1 six sided die, five foot piece of felt, rubber/plastic, and concrete/asphalt/grass or other rough surface, a ruler, graph paper, and a TI-80 calculator.

Procedures:

1. Write a hypothesis for the probability of rolling a "6" while rolling the die on different surfaces.

Hypothesis:

_____
_____
_____

2. Using the ruler, drop the die 24 times from a height of 5 inches on a five-foot long felt surface. Record your results on a separate sheet.

3. Drop the die 24 times from a height of 5 inches on a five-foot long plastic or rubber surface. Record your results on a separate sheet.

4. Drop the die 24 times from a height of 5 inches on a five-foot long sections of playground (note whether the surface is concrete, asphalt, grass, etc.). Record your results on a separate sheet.

5. Create a frequency chart using the results of this experiment.

Side of Die

	1	2	3	4	5	6
FELT						
RUBBER						
CONCRETE						

Based on 24 trials at each height

6. Create a histogram illustrating the frequency of rolling a "6" on different surfaces.

Questions

1. What are the odds of rolling a "6" on each of the three surfaces?

2. How does your data compare to your hypothesis?

3. What kind of graph would best represent the results of this experiment? Explain why you would choose this type of graph.

4. Does gravity effect the probability of rolling a given number on a die? Explain your answer.

Student Assessment

Name_____

Date_____

You have completed three experiments which tested the effects of gravity on the probability of rolling a given number on one die. You have also analyzed the data from these three experiments and have made some interesting discoveries. **NOW….**

Directions: Develop a fourth experiment using equipment other than dice to demonstrate what, if any effect gravity has on probability. Some suggested materials might be: spinners, bingo balls, coins, a deck of cards, etc.

Your experiment **must** include the following elements:

A hypothesis
List of materials which are easily obtained
Easily followed directions (step by step)
Specific directions for data collection, organization, and analysis (graphing calculator must be used!)
A minimum of **three good** questions about the results of the experiment

NOTE When completing this assessment follow the form in which Experiments #1, #2, & #3 were written.

SCORING RUBRIC

This assessment will be worth five points. One point will be given for each of the principle parts of the experiment which are listed above.

Good Luck!!!

SCORING CHECKLIST

	YES	NO
Hypothesis		
Materials		
Directions		
Data Directions		
Questions		

Directions: Make a check mark in the appropriate box. There is one point assigned to each part of the experiment. When all parts are checked, add the total number of Yes notations. This is the total point value the student receives for the assessment.

Student Name_____

Student's Total Score_____

Extension 2
HALF-LIFE

Objectives:

Students will:

- Compare stable and unstable (radioactive) isotopes.
- Describe alpha particle, beta particle, gamma ray.
- Explain and apply the concept of half-life.
- Estimate probabilities from data collected in repeated trials of an experiment.
- Use the graphing calculator to evaluate results.

Materials/Resources/Printed Materials:

- TI-80 Graphing Calculator (or equivalent device)
- Periodic table
- Half-life activity sheets
- M & Ms
- Paper cups and paper plates

Development/Procedures:

- Distribute activity sheet # 1. Review and discuss with students.
- Give students activity sheet #2. Monitor progress. Allow 10-15 minutes. Review questions with students.
- Distribute periodic table, markers, and activity #3. Instruct students to follow directions carefully. Review activity #3.
- Review probability by using TI-80.

Evaluation:

Half-Life experiment will serve as the assessment tool. Students are asked to demonstrate their understanding of Half-Life and probability. Students will graph their results, use a data, complete analysis and conclusions, and write reflections (three or more statements detailing what they have learned as a result of completing this experiment).

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Worksheet for Experiment #1

Name_____

Date_____

KEY CONCEPTS

The nucleus of a stable isotope does not change. The nucleus of a radioactive isotope changes to form a nucleus of a new element. Radioactive decay is the spontaneous breakdown of the nucleus of a radioactive element to form another nucleus.

UNDERSTANDING RELATIONSHIPS

Explain how the following groups of terms are related.

1. Isotopes: radioactive isotopes

2. Alpha particle: beta particle: gamma ray

3. Nuclear radiation: radioactive: radioactivity

Worksheet for Experiment #2

Name _____

Date _____

Types of Radiation

Write the type of radiation being described. If the item describes alpha radiation, write alpha before the item; if it describes beta radiation, write beta before the item; if it describes gamma radiation, write gamma.

_____ 1.	Can easily go through the human body.
_____ 2.	Consists of 2 protons and 2 neutrons
_____ 3.	Made of high-speed electrons
_____ 4.	Can be stopped by a sheet of paper
_____ 5.	Is formed when a neutron breaks apart
_____ 6.	Can pass through 30 mm of lead
_____ 7.	Is a helium nucleus
_____ 8.	Particle much smaller than alpha particle
_____ 9.	High-energy wave much like x-ray
_____10.	Is the weakest type of radiation.

Worksheet for Experiment #3

Radioactive and Nonradioactive Elements

Name_____

Date _____

1. Use the copy of the periodic table.
   (Student Resource #1)

2. Use blue to show which elements are radioactive, use green to show which elements are nonradioactive, and use orange to show which elements are synthetic.

3. Describe the pattern you see. Which elements are unstable? Stable?

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Assessment
Half-Life

Name _____

Date_____

Purpose: To simulate half-life with a radioactive isotopes.

Materials: M & Ms, TI-8O calculator, paper plates, paper cups, data chart (Student Resource #2)

Procedure

1. Divide into teams of three or four students.

2. Prepare a data table.

3. Place M & Ms in a paper cup. The M & M's represent atoms of a radiaoactive isotope.

4. Shake the cup of M & Ms and dump them into a paper plate.

5. The M & Ms that show the Ms represent those which have undergone radioactive decay to form the stable isotope. Count them and complete the information for trial one in your chart.

6. Do not put the stable isotopes back into the cup. Set them aside.

7. Put only those M & Ms with the Ms showing, back into the paper cup. These represent nuclei which have not yet undergone radioactive decay.

8 . Repeat steps 4-7 until you have removed all the M & Ms.

Analysis and Conclusions

1. Use the graphing calculator to make lists of the data and graph that data by making a graph that best represents the team's results. Label the vertical axis "number of radioactive nuclei". Label the horizontal axis" trial number". Sketch a picture of the graph as it appears on your calculator.

2. What is the shape of your team's graph? Describe in words.

_____

_____

_____

_____

3. How many tosses are required to remove one half of the M & Ms? Describe in words.

_____

_____

_____

_____

4. Assuming tosses are equal to years, what is the half-life of the M & Ms? Describe in words.

5. Describe a real-world application for M & Ms half-life experiment.

Extension 2
HALF-LIFE

Key
Experiment #1

1. Isotopes are atoms with the same number of protons and different number neutrons. Their nuclei are stable.

   Radioactive isotopes are unstable isotopes. Their nuclei will change to form a different element. Radioactive isotopes have different number of protons and different number of neutrons.

2. Alpha particle, beta particle, gamma ray are the three natural types of radiation.

3. Nuclear radiation is composed of particles and rays that are given off from the nucleus of an atom.

   Radioactive a process by which the nucleus gives off nuclear radiation to become stable.

   Radioactivity the release of energy and matter resulting from changes in the nucleus of an atom.

Key
Experiment #2

1. gamma ray
2. alpha particle
3. beta particle
4. alpha particle
5. beta particle
6. gamma ray
7. alpha particle
8. beta particle
9. gamma ray
10. alpha particle

Key
Experiment #3

2. Elements with atomic numbers 43, 61, and 84-109 are radioactive All other elements with an atomic number of 83 or less are not radioactive.
   Synthetic elements have atomic numbers of 93 or greater.
3. Radioactive elements are unstable. Nonradioactive elements are stable.

Key
Assessment

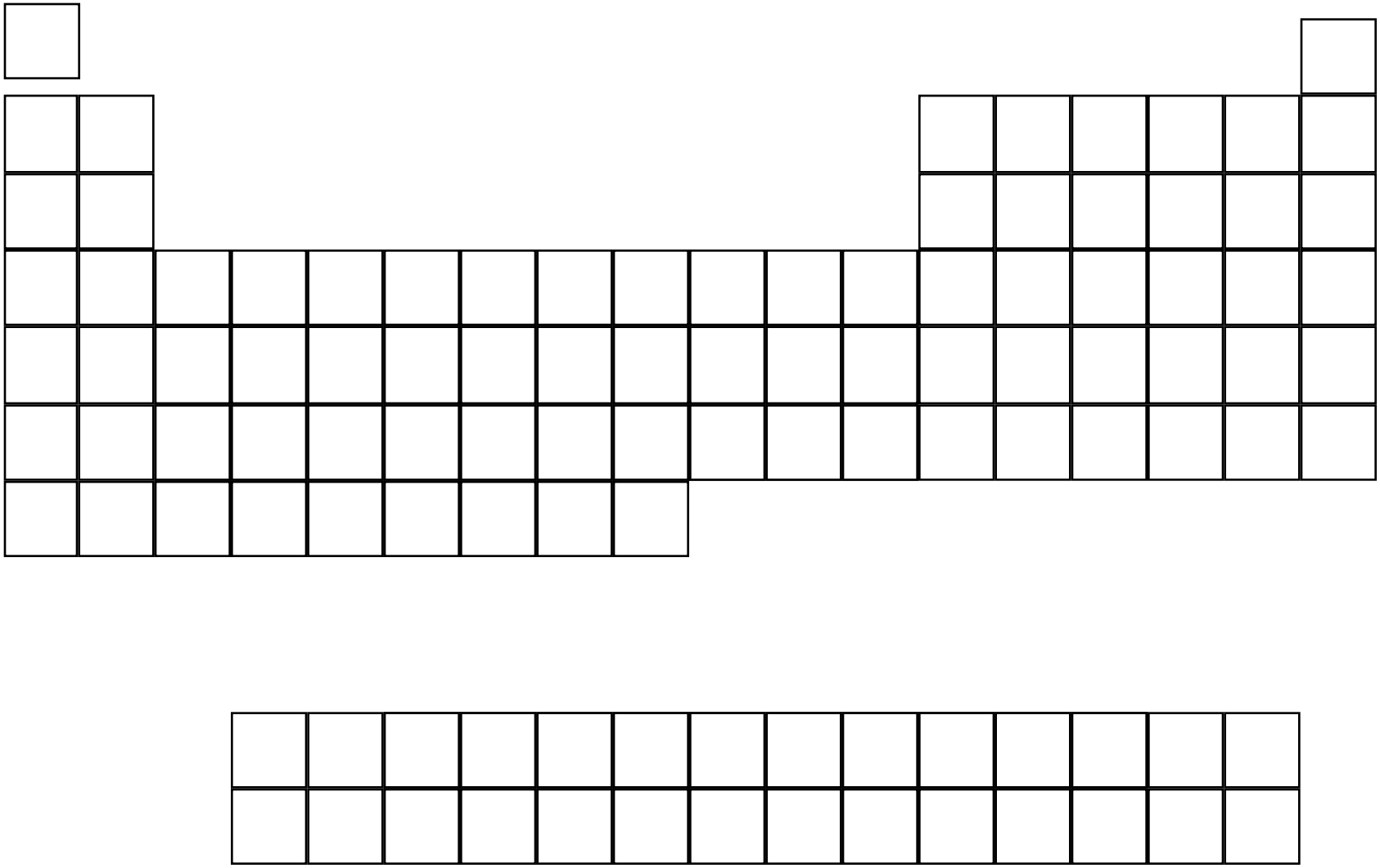
2. Exponential regression
3,4,and 5 will depend on probability outcomes.

M&M TOSSING EXPERIMENT

OUTCOME	M&M	PLAIN
TOSS 1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
TOTALS		

The Periodic Table

Student Resource #1



Scoring Rubric

4
- Task response is clearly developed, complete and accurate.
- Includes descriptive model or diagram. Communicates effectively to audience with strong supporting argument.
- Shows understanding of mathematical ideas and processes.
- Considers all factors, includes examples and may include counter examples.

3
- Task response is clear, fairly complete, and accurate Includes an appropriate model or diagram. Communicates effectively to audience with some supporting arguments.
- Shows general understanding of mathematical ideas and processes.
- Includes many of the important elements of problem and may include an example.

2
- Task response is partially developed but explanation may be muddled.
- Model or diagram may be inappropriate or unclear. Attempts to communicate effectively with audience but arguments may be incomplete.
- Lacks full understanding and may include major strategy or computation errors.
- Ideas show little or no elaboration.

1
- Task response is attempted but may be incomplete. Model or diagram is missing.
- Communication misuses or omits math concepts. Shows little understanding and may include major effort.
- Ideas are weak and may misrepresent the problem situation.

NSR
- Blank
- Unable to begin task
- Attempts wrong task
- Illegible, non-readable, or non-decipherable

Extension 3
GENETICS

Objectives:

Students will:

- classify gene pairs as dominant, recessive or hybrid.
- use data to predict trait outcomes.
- experiment to test mathematical predictions.
- compare test results to predictions.

Materials/Resources/Printed Materials:

- Worksheets
- Recording sheets
- Pennies
- Nickles
- Pen or pencil

Development/Procedures:

- Review dominant and recessive traits.
- Work with a group or partner to complete data grids and calculate predictions.
- Complete experiments to test predictions.
- Compare predictions to experimental data, analyses and write conclusions.

Evaluation:

Students will solve a related problem, using mathematical predictions and experimental test data. Data will be organized and conclusions written.

Author:

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Worksheet for Experiment #1

Name_____

Date_____

PREDICTING OUTCOMES IN GENETIC TRAITS

Our many genes determine our characteristics. They come in pairs. One from each pair comes from the male, the other from the female parent. Some traits are hidden or **recessive**. Some traits are always expressed or **dominant**.

Pure Recessive = 2 Recessive Genes = Recessive Trait
Pure Dominant = 2 Dominant Genes = Dominant Trait
Hybrid = 1 Dominant and 1 Recessive = Dominant Trait

ACTIVITY 1

MAKE TRAIT PREDICTIONS
USING DATA GRIDS(Punnett Squares)

1. Parents (pure dominant- DD and pure recessive- rr)

	D	D
r		
r		

What is the probability of

a) pure dominant offspring?_____(%or fraction)
b) pure recessive offspring?_____
c) hybrid offspring?_____
d) All offspring will have_____trait.

2. Parents (both hybrid - Dr and Dr) (Dom./recess.)

	D	r
D		
r		

What is the probability of

a) pure dominant offspring?_____
b) pure recessive offspring?_____
c) hybrid offspring?_____
d) a dominant trait?_____

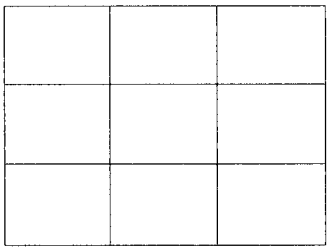
3. Parents (pure dominant -DD and hybrid -Dr)

	D	D
D		
r		

What is the probability of

a) pure dominant offspring?_____
b) pure recessive offspring?_____
c) hybrid offspring?_____
d) a dominant trait?_____

4. Set up your own data grid using a pure recessive - rr and a hybrid parent -Dr.



What is the probability of

a) a dominant trait?_____
b) a recessive trait?_____

5. Use your data grids to solve these probabilities.

In Guinea Pigs curly rough hair is a dominant trait and smooth hair is a recessive trait. Calculate the probability for curly rough hair or smooth hair for offspring of the following sets of parents:

a) pure curly rough and hybrid

curly rough hair-_____(% or fraction)
smooth hair-_____

b) both hybrid

curly rough hair-_____
smooth hair-_____

c) pure smooth and hybrid

curly rough hair-_____
smooth hair-_____

Worksheet for Experiment #2
EXPERIMENT TO CHECK PREDICTIONS

Name_____

Date_____

PROBLEM - How accurate are calculated probabilities?
MATERIALS - (EACH GROUP)

data table
pencil or pen
2 nickles
2 pennies

PROCEDURES -

1) Collect data for parents that are **pure dominant and pure recessive**.
(dominant is curly smooth, recessive is smooth hair)
2) Use 1 penny, for the pure recessive , and one nickle, for the pure dominant.
3) Decide what a good sample number for this experiment should be.
4) Repeat for 2 **hybrid** parents.
5) Use 2 coins, heads for dominant trait and tails for recessive trait.
6) Record data for at least 20 tosses of the coins.
7) Repeat steps for parent sets - **pure dominant & hybrid**
- pure recessive & hybrid

QUESTIONS -

1.) How did your predictions compare to you collected data?

2.) What variable in your experiment could be changed to alter you outcomes?

3.) Were there conditions that might have effected your data collection?

4.) How might these prediction be useful to farmers?

DATA SHEET
COIN TOSSING EXPERIMENT

Name ___________
Date ___________

Trait: ___________

Parents: ___________

TOSS		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
TOTALS		

Trait: ___________

Parents: ___________

TOSS		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
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16		
17		
18		
19		
20		
TOTALS		

Trait: ___________

Parents: ___________

TOSS		
1		
2		
3		
4		
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12		
13		
14		
15		
16		
17		
18		
19		
20		
TOTALS		

Trait: ___________

Parents: ___________

TOSS		
1		
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18		
19		
20		
TOTALS		

ASSESSMENT

GENETICS

Name _____

Date_____

A rabbit breeder is preparing for his next Easter season sales. He has orders for 50 long haired rabbits and 25 short haired rabbits. He's worried because long hair is a recessive trait and all his breeding pairs are hybrid for hair type. If he averages 4 bunnies per litter, how many pairs must he breed to fill his orders.

Be sure to :

1) calculate predictions
2) test results
3) label and organize data
4) analyse and compare
5) write a summary

Answer Key

Activity #2--PREDICTING OUTCOMES IN GENETIC TRAITS

Our many genes determine our characteristics. They come in pairs. One fromeach pair comes from the male, the other from the female parent. Some traits are hidden or **recessive**. Some traits are always expressed or **dominant**.

Pure Recessive = 2 Recessive Genes = Recessive Trait
Pure Dominant = 2 Dominant Genes = Dominant Trait
Hybrid = 1 Dominant and 1 Recessive = Dominant Trait

ACTIVITY 1
MAKE TRAIT PREDICTIONS
USING DATA GRIDS (Punnett Squares)

1. Parents (pure dominant- DD and pure recessive- rr)

	D	D
r	Dr	Dr
r	Dr	Dr

What is the probability of

a) pure dominant offspring?__**0%**__(%or fraction)
b) pure recessive offspring?__**0%**___
c) hybrid offspring?_**100%**___
d) All offspring will have_**dominant**__trait.

2. Parents (both hybrid - Dr and Dr) (Dom./recess.)

	D	r
D	DD	Dr
r	Dr	rr

What is the probability of

a) pure dominant offspring?_**25%**_____
b) pure recessive offspring?_**25%**_____
c) hybrid offspring?_**50%**_____
d) a dominant trait?_**75%**_____

3. Parents (pure dominant -DD and hybrid -Dr)

	D	D
D	DD	DD
r	Dr	Dr

What is the probability of

a) pure dominant offspring?_**50%**_____
b) pure recessive offspring?_**0%**_____
c) hybrid offspring?_**50%**_____
d) a dominant trait?__**100%**_____

4. Set up your own data grid using a pure recessive - rr and a hybrid parent -Dr.

	r	r
D	Dr	Dr
r	rr	rr

What is the probability of

a) a dominant trait?_**50%**_____
b) a recessive trait?_**50%**_____

5. Use your data grids to solve these probabilities.

In Guinea Pigs curly rough hair is a dominant trait and smooth hair is a recessive trait. Calculate the probability for curly rough hair or smooth hair for offspring of the following sets of parents:

a) pure curly rough and hybrid
curly rough hair-__**100%**_____(% or fraction)
smooth hair-__**0%**_____

b) both hybrid
curly rough hair-__**75%**_____
smooth hair-__**0%**_____

c) pure smooth and hybrid
curly rough hair-__**50%**_____
smooth hair-__**50%**_____

Answer Key

Activity #2--EXPERIMENT TO CHECK PREDICTIONS

PROBLEM - How accurate are calculated probabilities?

MATERIALS - (EACH GROUP)

data table
pencil or pen
2 nickles
2 pennies

PROCEDURES -

1) Collect data for parents that are **pure dominant and pure recessive.**
   (dominant is curly smooth, recessive is smooth hair)
2) Use 1 penny, for the pure recessive , and one nickle, for the pure dominant.
3) Decide what a good sample number for this experiment should be.
4) Repeat for 2 **hybrid** parents.
5) Use 2 coins, heads for dominant trait and tails for recessive trait.
6) Record data for at least 20 tosses of the coins.
7) Repeat steps for parent sets - **pure dominant & hybrid**
   - pure recessive & hybrid

QUESTIONS -

1.) How did your predictions compare to you collected data?
answers will vary

2.) What variable in your experiment could be changed to alter you outcomes?
number of outcomes tested

3.) Were there conditions that might have effected your data collection?
coins worn or weighted, human error

4.) How might these prediction be useful to farmers?
better able to plan crop or livestock outcomes

Scoring Rubric

4	- Task response is clearly developed, complete and accurate. - Includes descriptive model or diagram. Communicates effectively to audience with strong supporting argument. - Shows understanding of mathematical ideas and processes. - Considers all factors, includes examples and may include counter examples.
3	- Task response is clear, fairly complete, and accurate. Includes an appropriate model or diagram. Communicates effectively to audience with some supporting arguments. - Shows general understanding of mathematical ideas and processes. - Includes many of the important elements of problem and may include an example.
2	- Task response is partially developed but explanation may be muddled. - Model or diagram may be inappropriate or unclear. Attempts to communicate effectively with audience but arguments may be incomplete. - Lacks full understanding and may include major strategy or computation errors. - Ideas show little or no elaboration.
1	- Task response is attempted but may be incomplete. Model or diagram is missing. - Communication misuses or omits math concepts. Shows little understanding and may include major effort. - Ideas are weak and may misrepresent the problem situation.
NSR	- Blank - Unable to begin task - Attempts wrong task - Illegible, non-readable, or non-decipherable